Understanding Variables in the TI-nSpire: Programming Variables vs. Algebraic Variables

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> "In computer science and mathematics, a variable (pronounced /ˈværiəbəl/) (sometimes called an object or identifier in computer science) is a symbolic representation used to denote a quantity or expression. In mathematics, a variable often represents an "unknown" quantity that has the potential to change; in computer science, it represents a place where a quantity can be stored. Variables are often contrasted with constants, which are known and unchanging."
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> en.wikipedia.org/wiki/Variable

Central to the powerful calculating, graphing and programming engine built into the Texas Instrument nSpire and nSpire CAS calculators is its variable storage structure that allows variables and functions to be shared between multiple applications running simultaneously. Putting this power into the hands of high school students taking Algebra I and Geometry for the first time can be a little overwhelming both for student and teacher alike. For a student struggling to understand the concept of the variable in mathematics, understanding the function of a variable within the nSpire may be particularly daunting. To be clear, variables within the nSpire behave more like variables within a programming language such as C, BASIC or Perl than like variables in an algebraic equation. This behavior, if explained well, can be used to create a deeper understanding of key Algebra I equations such as the Linear Equation in *Slope-Intercept Form* ($y = mx + b$) and the Quadratic Equation in *Standard Form* ($y = Ax^2 + Bx + C$).

The Linear Equation in *Slope-Intercept Form* is perhaps the most essential concept in Algebra I. This equation is written

$$y = mx + b$$

Teaching this equation to students can be particularly challenging. During the first semester of Algebra I, students have just been introduced to the idea of the variable, a letter that represents an "unknown". Now students are asked 1) to understand that y and x are **variables** and 2) that m and b are **constants** representing *slope* and *y-intercept*, respectively. Students must be wondering, why do some letters (x,y) represent variables, while other letters (m,b) are constants. It is here that the nSpire's variable structure used with the graphing application can help students make the distinction.

Building an nSpire Document for Investigating the Slope-Intercept Equation

1. Create a New Document with a Calculator Application
2. Define new variables to represent *slope* and *y-intercept*.
   a) Type "`define m=1`" and press enter.
   b) Type "`define b=0`" and press enter.
   c) Type "`define f1(x)=m`×`x+b`" and press enter.
   d) Insert a *Graphs & Geometry* into the Current Problem.
   e) Use the cursor to select *f1(x)* and press enter. This will graph *f1(x)* into the *Graphs & Geometry* application.

Explaining the Document

The purpose of this lesson is to introduce students to the linear equation in *Slope-Intercept Form*. Students will understand that the linear equation is the mathematical representation of the graph of a straight line. Students will understand the meaning of *y*, *m*, *x* and *b*. Students will understand that *x* and *y* are the independent and dependent variables and what effect changing *m* and *b* will have on the graph of the linear equation.

In order to teach these, students must understand the distinction between *variables* and *constants*. Mathematically, we are working with two variables, *x* and *y*. Internal to the Current Problem we have created within the nSpire, we are working with two variables, *m* and *b*. The distinction between these two different kinds of variables can be understood as the distinction between variables in a programming language and algebraic variables. Programming Variables are placeholders to which we assign discrete values that will not vary unless we explicitly change them. That is, the variables within the nSpire, our Programming Variables, should be understood mathematically as **constants** - they have discrete values that are being stored by the nSpire variables *m* and *b*. Algebraic Variables in a Linear Equation are constantly varying, one depending upon the other. Our mathematical variables mirror *x* and *f1(x)* within the nSpire which are used to create the graph of the Linear Equation and should be understood as **variables**.

Using the Document

Students will gain a more profound understanding of these variables and constants and how they are used by working with them. Students should use the *Calculator* Application to change the values of *m* and *b*. In doing so, they will see that these values can change, but they are still constants, as each change to the value of *m* or *b* creates a change in the appearance of the graph of the Linear Equation in the *Graphs & Geometry* Application and a change in the equation itself. In other words, each change to ***m*** or ***b*** creates an entirely new Linear Equation to be manipulated. As students make these changes they should be asked to observe what effect the changes have on the equation and the shape of the graph and to record these observations as part of their classwork.

Students should first vary the values of *m*.

a) Type "`2→m`" [1] and press enter. This can be understood as telling the nSpire to store a value of 2 in the placeholder we have created named ***m***.
b) Have students use the *Slope-Intercept Form* of the Linear Equation to express mathematically the equation that is currently being graphed (*i.e. y = 2x*).
c) Have students check the *Graphs & Geometry* Application to see what the effect of changing the *m* value was.

Repeat these steps for multiple different values of *m* including negative values, fractional values, zero and very large (approaching infinite) values. Students should then use this procedure to vary the values of *b* for positive, negative, large, small and zero values. After each change, students should observe their graph and record their observations.

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[1] Press ctrl + sto→ var to type →.

Conclusion

During this introductory lesson, at no time have we referred to the placeholders ***m*** and ***b*** stored within the nSpire as "variables", even though, this is how the nSpire understands them. If we wanted to eliminate either ***m*** or ***b*** from the nSpire's memory, we would have to select the *Delete Variable* function from the *Calculator* Application's *Tools Menu*. Eventually, students will need to understand that within the nSpire, ***m*** and ***b*** are variables. Hopefully having worked with ***m*** and ***b*** as discrete value placeholders in the context of a Linear Equation and its graph, students can come to understand the distinction between Programming Variables within the calculator and the Algebraic Variables x and y that they use to create their Linear Equation and that are used by the *Graphs & Geometry* Application to create their graph. As an extension to this activity, students can explore the effect that changes to ***A***, ***B*** and ***C*** have on the equation and graph of the Quadratic Equation in *Standard Form* ($y = Ax^2 + Bx + C$).